Design of Tooth-Locked Quick Open-die Pressure Vessel

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Abstract

In accordance with the foreign relevant standards, this paper designs the high pressure horizontal tooth-locked quick closure pressure vessel, then put the emphasis on the design and intensity checking of the quick opening device according to the provided parameter requirements. This design method provides reference to structural design of similar equipments as well as to drawing a set of suitable design method for quick opening device.

Keywords

Pressure Vessel, Tooth-Locked , Quick Open-Die Processes

Introduction

Pressure vessel with quick on-and-off cover— (the quick-opening pressure vessel for short) means the one which can achieve opening and closing by rotating the cover for a certain angle or moving the locking component for a certain distance. As there is no need to tighten or loosen bolts individually, the on-and-off time of quick-opening pressure vessel is very short, which contributes to the convenience of loading and unloading for goods, so it has been widely applied in frequently intermittent industries such as chemicals, building materials, food, textile, aerospace, healthcare industry, papermaking and so on. Although there are different kinds of quick-opening pressure vessels, this paper studies the geared quick-opening pressure vessel, which provides a basis for the design of high-pressure welding experiment module.

Design Conditions And Main Technical Parameters

The Main Criteria and Parameters

The research is carried out according to JIS - 8284—2003 Japanese Industrial Standard -Pressure vessel with Quick On-and-Off Cover, JIS B 8281--1993 The Stress and Fatigue Analysis of Pressure Vessel, and JB4732 Analysis and Design Standard of Steel Pressure Vessel.

The main design parameters: (1) the design pressure is 16MPa; (2) the design temperature is 100℃; (3) the inner diameter of the cylinder body is 1100mm; (4) the corrosion allowance is 2mm; (5) the cylinder material is 20MnMo; (6) the weld coefficient is ϕ= 1.0; (7) the working medium is argon; the allowable stress under design temperature is σa = 204MPa.

Conditions of the fatigue life is shown as follows: (1) Design life: 15 years; (2) The number of operations: 1500 times/year; (3) The total number of cycles: 15 x 15 = 22500.

Judging Criteria of Stress of Geared Structure

Allowable stress of evaluation position of geared quick-opening device is shown as follows (in Fig.1): the stress S1 at flange neck is $1.5\sigma_a$ (σ_a is the allowable stress 204MPa of the material), the longitudinal shear stress S2 at the root of flange claw is $0.8\sigma_a$, bending stress S3 at the root of flange claw is $1.0\sigma_a$, the longitudinal shearing stress S4 at the junction of flange ring and flange neck is $0.8\sigma_a$, the peak stress S5 at the flange corner is 640 MPa (according to the fatigue analysis provisions of JIS B8281), the longitudinal stress S6 of clamp is $1.5\sigma_a$, the shearing stress S7 at the root of the clamp and claw is $0.8\sigma_a$, the bending stress S8 at the root of the clamp and claw is $1.0\sigma_a$,the bearing stress S9 of the clamp and claw as well as the flange claw is $1.6\sigma_a$, the peak stress S10 at the claw corner is 640 MPa (according to the fatigue analysis provisions of JIS B8281), the shearing stress S13 at the root of claw of flat cover plate is $0.8\sigma_a$,the bending stress S14 at the root of claw of flat cover plate is $0.8\sigma_a$,and the peak stress at the root of claw of flat cover plate is 640 MPa (according to the fatigue analysis provisions of JIS B8281).

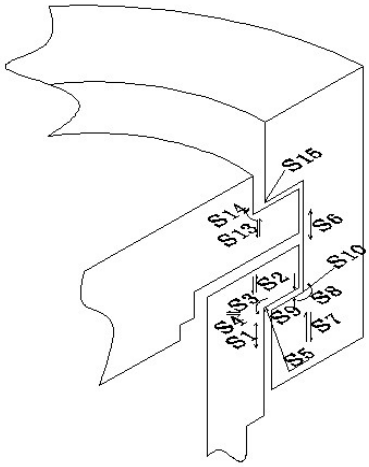

FIG. 1 THE EVALUATION STATUS AND LOCATION OF THE STRESS OF GEARED STRUCTURE

Structural Parameters and Calculations

Structural Parameters

Geared quick-opening structure is characterized with uniform teeth at a head cover flange and end flange in the circumferential direction. The meshing and staggering of head cover flange teeth and the end flange teeth can be achieved in quality supervision through rotating the head cover flange at a certain angle so as to achieve the purpose of quick opening.

The geared structure is designed and calculated in accordance with JIS B 8284 standard,in addition, the size and symbols of the geared quick-opening structure are shown in Fig. 2.

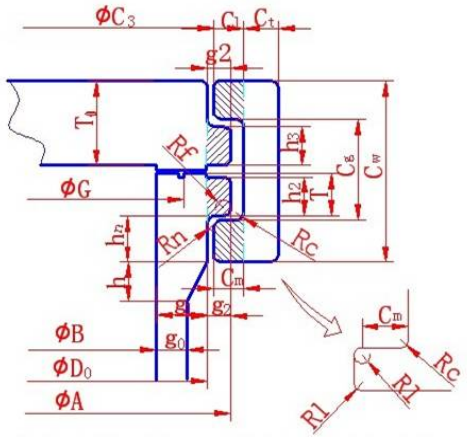

FIG. 2 THE PROFILE SCHEMATIC OF QUICK-OPENING STRUCTURE AND THE SIZE SYMBOLS

In this paper, the value of examples is taken as follows: the outer diameter of clamp ring D0=1320mm, the outer diameter of flange claw A=1480mm, the inner diameter of cylinder body or the flange ring B = 1100mm, the outer diameter of contact surface of clamp claw and flange claw C1=1456mm, the inner diameter of contact surface of clamp claw and flange claw C2=1344mm, the inner diameter of the top of clamp claw C3=1344mm, the distance between the inner edges of clamp Cg=240mm, the length of clamp cylinder body Ct=100mm, the length of clamp Cw=470mm, the outer diameter of flange neck D0=1320mm, the outer diameter of gasket G=1200mm, the thickness of the top of flange hub g0=60mm, the thickness of the flange neck g1=110mm, the length of flange claw g2=80mm, the length of flange hub h=80mm, the number of claws n=16, the length at the root of clamp claw L=151mm, the fillet at the corner of body-flange and cover r = 12mm, the length of flange ring T = 90mm, the cover thickness T0=290mm, and Poisson's ratio $\nu = 0.3$.

Calculation Results

(1) The load on the inside diameter area of flange of internal pressure: F=1.52×107N

(2) The torque generated on the contact surface of clamp ring and flange neck: MH=1.75×109N·mm

(3) The difference between the total load of the internal pressure and the load imposed on the inner diameter area of flange: HT=2.89×106N·mm

(4) The torque generated by the difference between the total load of the internal pressure imposed on flange and the load imposed on the inner diameter area of flange: MT=3.7×108N·mm

(5) The shearing force generated on the contact surface between the flange ring and flange neck: QH=9.2×106N·mm

(6) Concentration factor of bending stress at the flange corner: KBF=1.82, concentration factor of tensile stress at the flange corner: KTF=2.23

(7) The bending stress at the flange corner: SBF=228.85 N, membrane stress at the flange corner: STF=36.36N

(8) The total torque acting on the flange: M0=2.2×109 N·mm

(9)The bending stress of the clamp: SBC=231.6N, the longitudinal membrane stress of the clamp: STC=37.11N

(10) Torque generated on the contact surface of the flange ring and flange neck: MH=1.75×109 N·mm, the shearing force generated on the contact surface of the flange ring and flange neck: QH=9.2×106 N·mm

(11)Concentration factor of the bending stress at the corner of clamp: SBC=1.77, concentration factor of tensile stress at the corner of clamp: STC=2.2

Stress Calculation and Checking

(1) The longitudinal stress on the outer surface of the flange neck: S1=132.60<1.5σa

(2) The longitudinal shearing stress at the root of flange claw: S1=140.26<0.8σa

(3) The bending stress at the root of flange claw :S3=170<1.0σa

(4)The radial shearing stress generated at the junction of the flange neck and flange ring: S4=32.89<0.8σa

(5) The peak stress at the flange corner: S5=498.19<2Sa(Sa=318MPa)

(6) The longitudinal stress of the clamp: S6=268.7<1.5σa

(7) The bending stress at the root of clamp claw S7=101.74<0.8σa

(8) The bending stress at the root of clamp claw: S8=182.8<1.0σa

(9) The bearing stress of the clamp claw and flange claw: S9=153.1<1.6σa

(10) The peak stress at the corner of clamp: S10=589.7<2Sa

(11) The shearing stress at the claw of the flat cover plate: S13=116.89<0.8σa

(12) The bending stress at the claw of the flat cover plate: S14=160.58<0.8σa

(13) The peak stress at the corner of the claw root of the flat cover plate: S10=410.2<2Sa

Other Security Requirements [11, 12]

(1) Operation and emissions

It is confirmed that light bulbs and buzzers must be installed in accordance with different states of the quick-opening device with various colors.

(2) Security devices

The safety interlock device that guarantees the security must be equipped, such as safety valves, relief valves, interlock device, etc.

(3) Confirmation at the start of the operation

At the beginning of the operation, it is ensured that various parts of the on and off cover device is assembled in the normal position by electrical or mechanical form before increasing the pressure.

(4) Confirmation at discharging

When the quick-opening cover discharges, it is ensured that there is no residual pressure within the pressure vessel by electrical form or pressure indicator before opening the cover;

(5) Records of use

When put into use, the automatic operating recorder must be applied to record the total number of usage.

Conclusions

Geared quick-opening device is designed in accordance with relevant standards. The pressure vessel is mainly applied to conduct high-pressure welding process test, which meets the requirements of high-pressure welding process test and provides reference to the relevant pressure vessel design.

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